Economic Analysis of Harvest Management Activities

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Economic Analysis of Harvest and Management Activities

Supplement to study "Evaluating visual impacts of New Perspectives Forestry", Lick Creek study area, Bitterroot National Forest

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Introduction

The purpose of the Lick Creek "New Perspectives" harvest is to demonstrate and test various silvicultural treatments aimed at enhancing timber productivity,bio-diversity, wildlife habitat, esthetics, and other ecosystem components. Principal interests in the cooperative research/management efforts are to evaluate the physical, biological, and visual effects of the management activities. An underlying concern for managers is the economic aspects such as efficiency and effectiveness of their actions.

This report analyzes the economic aspects of the harvesting operations, including pre and post harvest activities. The analysis is based primarily on accounting type records of hours, costs, volumes, and production. The basic approach is to compare operations among harvest units that had different prescriptions as described in the various Lick Creek study plans. Detailed "engineering" typeanalyses such as time and motion studies were not attempted. Rather, a bottom line approach deriving averages for each unit was used. As with any case study such as this, results may not apply to other areas, but cost differences and their possible causes are noted.

The Bitterroot N.F., Darby District provided data on pre- and post- harvest activities.The Intermountain Research Station and the University of Montana Forestry School provided information on stand characteristics and prescriptions. The contract logger, Larry Mahe generously provided day by day work records, and the purchaser, Champion, provided log scale data.

The sale area is located along Lick Creek in low to middle elevation mixed ponderosa pine and Douglas-fir forest. The harvest units are on gentle to moderately steep rolling terrain. Three units (# 2,3,&4) were research study units. Units 2&3 had some adverse grade skidding. Unit 4 had steeper slopes but mostly downhill skidding. Several non-research units were included in this analysis for comparison purposes. Unit 1 was a level to rolling unit with an estimated one-third adverse grade. Units 6&11 were small units on fairly steep ground with little adverse grade but longer skidding distance to the landing.

Logging Operations

All units were tractor logged to existing roads. Non-research unit #1 was similar to research units 2&3 in terrain with mostly level or gentle slopes, a few steeper pitches, and a small amount of adverse grade skidding. Units 6&11 were small but otherwise similar to unit 4 with mostly moderate to steep slopes and almost all downhill skidding.

Table 1 shows the area, harvest volume and piece counts for the units included in this analysis. Research unit 2 was predominantly a seral ponderosa pine stand with a few scattered old growth trees and a Douglas-fir understory. The silvicultural objective was to make a shelterwood cut, reducing the basal area from approximately 116 sq.ft./acre to about 50 sq.ft..

Unit 3 was an uneven age stand and the objective was to use individual tree selection harvest favoring ponderosa pine, reducing the basal area from about 100 sq.ft. to approximately 50 sq.ft..

Unit 4 was an even age stand of nearly pure ponderosa pine which was previously thinned. The objective here was to thin the stand from 90 sq. ft. basal area to about 50 sq. ft.

Both units 2 and 3 had a considerable portion of the harvest volume in larger stems, 18"+ dbh. Unit 4 had virtually no larger stems and relatively few trees under 6"dbh since it had been previously thinned. The size of the trees harvested is reflected in the number of pieces per Mbf., shown in table 1. This is commonly an important factor in logging costs. Unit 1 was similar to unit 2 in pieces per Mbf., but the harvest volume per acre was less. Units 6 and 11 were similar to unit 4 in pieces per Mbf., but had much larger harvest volumes per acre. The non-harvest units were individually tree marked for intermediate harvest.

In the non-research units, trees were felled, limbed, and skidded to roads, and slash was tractor piled for burning. In research units somewhat different methods were used. In units 2&3 trees were felled and skidded whole-tree to roadside landings.Some crown material was broken off in this process,

Table 1 . Area, Volume, and Pieces (logs) by Unit

Unit	Acres	Cruise vol,Mbf	Scale vol. Mbf	Mbf/a	Pcs/Mbf
1	152	442	436	2.87	24.27
2	75	353	408	5.44	22.69
3	130	398	358	2.75	20.89
4	81	107	124	1.53	31.77
6	7	62	54	7.71	29.66
11	6	45	39	6.50	29.66

and together with undesirable smaller or defective trees formed the slash remaining on site. At the road, trees were limbed and slash piled for burning. In skidding, the goal was to obtain 20% to 30% scarification.

In unit 4 trees were felled and the tops were bucked and left on site. Boles with limbs were skidded to the road and limbs slashed for burning.

Skid trails were pre-flagged with the aim of not less than 100' between skid trails to disperse soil disturbance and compaction.

Logging productivity

In order to compare logging operations productivity among the different treatments and units, man and machine hours for each of several phases of work were summarized. Down time and various conditions encountered were also reported by the operator which aided in the analyses of data.

In the analyses that follow, the volumes and piece counts used were based on log receipt data provided by the purchaser (Champion). The sale cruise volumes were in most cases fairly close, and it was felt the scale volumes which are tied to piece counts best reflect the actual logging productivity.

It was noted above that non-research unit 1 had terrain most similar to units 2 and 3, and non-research units 6 and 11 similar in terrain to research unit 4. On the other hand, the volumes and piece counts were not as comparable: Unit 2 had about twice as much harvest volume as units 1 and 2. Research unit 4 had only about one-fourth the volume and one-third the number of merchantable pieces as units 6 and 11.

With these two factors-- terrain and volume/piece count per acre -- tending to offset, it was difficult to determine the extent to which harvest prescription actually affected logging productivity.

Logging productivity expressed in volume and pieces per hour is summarized in table 2.Saw and landing includes man and chainsaw hours; tractor includes crawler tractor and operator. For the most part, the tractor operator did his own hooking, and the landing man the unhooking of the logs.

In units 2 and 3, productivity was somewhat greater than in non-research unit 1, except for landing man productivity. It appears that whatever the effect the silvicultural

Table 2. LOGGING PRODUCTION RATES

	Mbf per hour			Pieces per hour		
Unit	Saw	Cat	Landing	Saw	Cat	Landing
1	.87	.81	1.30	21.12	19.78	31.58
2	1.11	1.11	.94	25.08	25.22	21.28
3	1.29	1.03	1.34	27.00	21.43	28.01
4	.59	.57	.76	18.76	18.24	24.32
6	1.00	.57	1.20	29.59	16.82	35.51
11	.34	.43	.81	10.09	12.89	24.17

prescription and restrictions had on sawing and skidding operations, the larger volumes per acre in unit 2 and the larger piece size in unit 3 probably contributed to greater productivity than in unit 1. The logging method may have affected productivity at the landing, since bringing in the whole tree in units 2 and 3 increased the amount of limbing at the landing and also in effect reduced the sawyers time, especially in unit 2 which had generally smaller trees with more limbs. Conversely, sawyers productivity was greater in unit 2 than in unit 1 where conventional limbing and bucking was done at the stump. Unit 3 had the same whole-tree skidding as unit 2, but had somewhat more trees that were larger and less limby than did unit 2.

In research unit 4, low harvest volume per acre appeared to have a notable effect on logging compared to units 1,2,and 3. Sawyer and landing productivity was somewhat less in unit 4 than in unit 6, and skidding was about equal. Non research unit 11 was generally lower in productivity than either units 4 or 6 The reasons for these differences were not clear from the data but it is apparent that the advantages of larger harvest volume per acre in units 6 and 11 did not offset other factors. Skidder productivity may have been in part affected by skidding distance; half or more of unit 4 had relatively short downhill skidding but units 6 and 11 were more remote and involved longer skid distances to the road. It is likely that in unit 4 low volume, small piece size, and steeper terrain all had some role in lowered productivity in this unit.

The above data compares logging productivity among units in terms of output per hour. For some purposes it is desirable to express this in terms of costs per unit of output. This is especially useful when looking at management activities, where costs per acre treated may be of interest. Table 3 presents "costs" of the logging operation, expressed as man-hours (includes saws and skidder) as reported by the logging contractor. The hours per Mbf are just the inverse of the Mbf per hour data, and reflect the same differences among units as discussed above. On a cost per acre basis, non research units 6 and 11 had much higher cost than other units, reflecting their small size. Unit 2 also had higher costs than units 1 an 3 which were similar; unit 2 was somewhat smaller than these units but also had higher harvest volume which would increase the per acre cost.

In order to further account for differences among units one further analysis was made, using a cost simulation model developed from past logging cost data.(Schuster and Niccolucci,1989). Out of numerous variables tested in building the model, six were found to significantly affect logging costs, and these were used to estimate costs for the Lick Creek units. This estimate of costs then can be considered as what costs would have been if all other factors except the variables considered were equal. The Lick Creek sale was somewhat smaller in both total volume and volume per acre than the average sale used in developing the model, and the authors caution that the model may not apply to widely different conditions. However, the model does provide another perspective on understanding costs for the Lick Creek units. The estimated stump-to-truck logging costs of each unit were as follows:(dollars per Mbf.)

Unit 1	105.90
Unit 2	73.47
Unit 3	98.87
Unit 4	161.21
Unit 6	80.64
Unit 11	84.01

Table 3.Logging cost expressed as hours per Mbf and hours per acre, by unit and logging activity.

	Hours / Mbf				Hours /Acre			
Unit	Saw	Skid	Land	Tot	Saw	Skid	Land	Tot
1	1.15	1.23	.77	3.15	3.30	3.52	2.20	9.02
2	.90	.90	1.07	2.87	5.27	5.24	6.21	16.72
3	.77	.97	.75	2.49	2.13	2.68	2.05	6.87
4	1.69	1.74	1.31	4.74	2.59	2.67	2.00	7.26
6	1.00	1.76	.83	3.59	7.71	13.57	6.43	27.71
11	2.94	2.30	1.23	6.47	19.17	15.00	8.00	42.17

The details of developing these costs are shown in appendix table 7 .These costs are in 1985 dollars per Mbf, the base year used in building the model (They could be converted to current dollars if desired). The significant indication is that costs predicted by the model show about the same variation among units as did the actual costs reported earlier.

Since the actual logging data is shown in man-hours per Mbf and the cost model predictions are in dollars, one way they can be compared is to use index numbers. In table 4 indexes are shown for actual costs and model estimates using unit 1, which was typical in terms of terrain and volume as a base of 1.0.

Both units 2 and 3 had costs somewhat lower than in base unit 1, in both the observed and cost model estimates. The details of the cost model (table 7, appendix) indicate the differences were probably related to average tree diameter and volume per acre, as was discussed earlier. In contrast, unit 4 was considerably higher in both estimated and observed costs; 1.52 and 1.50 times higher, respectively. Both units 6 and 11 had higher observed costs than unit 1, but the cost model estimated costs should have been considerably lower, due to larger volumes per acre. Two factors may explain this discrepancy; the fact that these were very small units, and the cost model may not be very applicable, and second, the long skidding distances discussed earlier were probably not typical of what would be the average skid distances in a larger area.

To summarize the analysis of logging costs,

-there were some differences in logging costs among units.

-the differences observed in actual costs were consistent with the cost model predicted costs.

Table 4. Index of logging costs per Mbf, actual data and cost model predictions.

Unit	Actual data	Cost model
1	1.00	1.00
2	.91	.69
3	.79	.93
4	1.50	1.52
6	1.14	.76
11	2.05	.79

-both the cost model and the actual cost data indicate cost differences may be in large part due to harvest volume per acre and average tree size.

-there was no clear indication that logging costs were affected by silvicultural prescription or logging restrictions. While these factors may have had some influence a more detailed time and motion type study would likely be needed to quantify them.

Other costs

In addition to the direct logging costs discussed above, the logger incurred some other additional costs including such items as erecting safety signs, marking skid trails, moving equipment and break-down time, seeding skid trails where needed, and brush piling and cleaning out roads. These costs are shown in table 5 . They were fairly consistent among units. Brush piling and trail marking accounted for most of these costs but there was considerable variation among units on these items. In addition to these costs the purchaser, Champion, indicated some units required additional blading on the roads due to the amount of slash debris that was ground into the roadbed when the road was used as landing. However, there was no records kept of this activity.

The Darby Ranger District provided data on Forest Service costs for cruising, marking, and sale preparation and administration. They reported that the cruising and marking costs for the entire sale was $12/Mbf, and that the research units required one extra person for computation and recording. These costs were then transformed into man-hour costs at rate of approximately $100 per person per day to derive the man-hour data shown in table 5 .Similarly, the sale preparation and administration were reported in man-hours and it was estimated the research units involved about 10% more time than the non-research units. The man-hours were then allocated across the total volume to derive the estimates in table .

Table 5 . Other logging costs and administrative costs, in man hours per Mbf.

Unit	Other log	Prep & Admin	Cruise & mark
1	.09	.71	.87
6	.13	.71	.87
11	.18	.71	.87
2	.12	.78	1.05
3	.16	.78	1.05
4	.17	.78	1.05

Post harvest

Logging was completed during summer and fall 1992 and slash burning begun in early summer 1993. In the research units two types of broadcast burning were used; wet burn and dry burn. The definitions of these and the management objectives are detailed in other Lick Creek study plans and reports. In general the objectives were to obtain two different degrees of burning intensity as the names imply. Unit 1 the non-research unit which had conventional limbing at the stump, was pile burned.

The Darby District provided hours and dollar data for burning activities. These are summarized in table 6 .Man hours for units 2 and 3 were converted to per acre basis from data provided. Unit 1 man-hours were derived from total cost figures. Vehicle costs were reported as totals per day and were allocated among units on the basis of acres burned. Patrol costs were allocated evenly over all units. Unit 4 was not burned in 1993 in time to be included in this report.

It is evident from table 6 that costs in the research units 2 and 3 were much higher than in unit 1, but since burning methods were different costs are not entirely comparable. It should be noted also that in the research units there was considerable interest and on-the-ground input among both administrative and research personnel and the number of people and their grade level was probably higher than would be utilized in ordinary conditions. Perhaps of even more impact, the different burn treatments were on much smaller areas than would normally undertaken and this had a significant impact on costs per acre. Probably the most significant information from table 6 is how costs were affected by size of the unit. For example, wet burn unit 2A, 7 acres, had "costs" of over 22 man-hours per acre but units 2B and 2C which were burned together totaled 22 acres and used just over 14 man-hours per acre. Similarly, unit 3C (5 acres) had the highest "cost" of all research units but 3A and 3B which totaled 10 aces had somewhat lower cost. Unit 2X totaled 30 acres and had the lowest cost of all research

Table 6 .Costs of post harvest burning, Lick Creek units.

Unit	Acres	Descrip	Man hrs/a	fuel,veh,misc $/a	Patrol $/a	Other
1	152	pile burn	.31-.45	1.97		
2A	7	wet burn	22.43	42.86		
2B	5	wet burn	14.32	13.64		
2C	17	"	"	"		
2X	30	dry burn	8.07	10.00	10.78	
3A	5	dry burn	21.60	30.00		
3B	5	"	"	"		
3C	5	dry burn	27.30	60.00		

} Indicates these units were burned together

units.

With costs apparently related primarily to unit size it is not possible to determine if the wet vs. dry burning had much affect on costs. Probably a qualitative judgement of this will be made by the fire personnel involved in the burning operations.

APPENDIX

APPENDIX

Table 7 Cost model estimate of stump-to-truck cost, Lick Creek Units, from Schuster and Niccolucci [1]

VARIABLE	Unit 1	2	3	4	6	11
Percent tractor	100	100	100	100	100	100
Mbf/a	2.87	5.44	2.75	1.53	7.70	6.50
Ave Dbh	12	14	14	10	11	11
Acres >55% slope	0	0	0	0	0	0
% Group Sel.	0	0	0	0	0	0
Acres	152	70	130	81	7	6

VARIABLE	Coeff.	Coeff. x unit values 1	2	3	4	6	11
CONSTANT	26.32	26.32	26.32	26.32	26.32	26.32	26.32
Percent tractor	-.33	-33.00	-33.00	-33.00	-33.00	-33.00	-33.00
1/Mbf/a	140.4	48.95	25.81	51.05	91.76	18.23	21.60
1/ave dbh	760	63.33	54.28	54.28	76.00	69.09	69.09
acres >55%	.1	0	0	0	0	0	0
% Gp Sel	.48	0	0	0	0	0	0
Acres^2	1.32×10^{-5}	.30	.06	.22	.09	.00	.00
Sum: (Estimated tot cost) (1985 dollars)		$105.90	73.47	98.87	161.21	80.64	84.01

[1] Schuster, Ervin G.; Niccolucci, Michael J. 1989. Predicting timber sale costs from sale characteristics in the Intermountain West. Res. Paper INT-406 Ogden, UT. USDA, Forest Service, Intermountain Research Station. 9p.